

Method of producing foamed slag

Description

The invention relates to a method of producing foamed
 5 slag in an arc furnace by the measured blowing of a
 carbon carrier by means of an oxygen carrier into the
 boundary layer between the slag layer and the molten
 metal and/or into the zones of the slag layer and/or of
 the molten metal that are adjacent to the boundary
 10 layer, in an amount such that the arcs are enveloped at
 least partially by a foamed slag layer.

The arc furnace which is used for melting metals and for
 producing high-quality steels uses the heat effect of an
 15 arc between a plurality of graphite electrodes either
 indirectly by heating the material to be melted only by
 the radiation of the arc, or by the material to be
 melted itself acting as an electrode of the arc. In
 addition to the arc, a further energy component is
 20 introduced by blowing finely divided carbon carriers
 together with oxygen carriers into the molten metal or
 into the slag layer. In addition, in order to form a
 foamed slag layer on the molten metal, finely divided
 carbon carrier is blown into the boundary layer between
 25 the slag layer and the molten metal, which boundary
 layer is substantially made up of the components iron
 oxide, calcium oxide, silicon dioxide, aluminium oxide
 and magnesium dioxide. The graphite electrodes, or the
 arc, and the furnace wall are enveloped by the foamed
 30 slag layer in such a manner that direct heat radiation
 at the furnace walls and at the furnace cover is largely
 avoided. A suitable proportion of carbon carrier and
 oxygen carrier must be present in order to foam the slag
 by the formation of CO/CO₂ bubbles. The high proportion
 35 of gas bubbles in the slag also reduces the direct
 conduction of heat in the foamed slag layer itself. The
 graphite electrodes immersed in the foamed slag layer,
 or the arcs between the molten metal and the

graphite electrodes, are largely protected by the foamed slag layer against the ingress of free oxygen from the atmosphere, so that the rate of combustion is reduced and the working life of the arc furnace is increased. In addition, the graphite electrodes are sometimes also sprayed with water in order to reduce the heat load and hence the rate of combustion.

The production of a foamed slag layer for covering the arcs in arc furnaces is described in DE-Z.: Stahl und Eisen, 106 (1986), No. 11, p. 625 to 630.

In order to ensure the advantages of an arc enveloped in foamed slag over a long period of time with minimum outlay, according to EP-A-0 637 634 level measurement of the height of the slag layer is carried out several times on a furnace charge and, by blowing solids, gases or a mixture of solids and gases into and/or onto the slag or the molten metal, a foamed slag layer enveloping an arc formed by at least one electrode is formed, the height of which foamed slag layer is such that the foamed slag layer extends at least over the entire arc.

There is also known a method or a device for controlling the formation of foamed slag in an arc furnace, to which carbon is fed in such a manner that the arc in the arc furnace is enveloped at least partially and, at the same time, the supply of an excessive amount of carbon is avoided. The amount of carbon fed to the arc furnace is determined by means of a foamed slag model, which is dependent on the amount of at least one of the charge materials scrap metal, steel, alloying agent or additives (DE-C-197 48 310).

The object of the present invention is to develop the method described at the beginning in such a manner that

the protective function of the foamed slag layer is improved.

That object is achieved by blowing into the arc furnace
5 finely divided titanium carrier, preferably having a mean particle size d_{50} of from 0.001 to 1.0 mm and a particle size of up to 5.0 mm.

Both natural and synthetic titanium carriers may be
10 used. However, natural titanium carriers have the disadvantage over synthetic titanium carriers that only relatively coarse-grained particles of up to 100 μ m are available. Owing to their specific properties, natural titanium carriers have a highly abrasive action on the
15 feed system and the blowing-in device, so that the blowing in of natural titanium carriers leads to frequent stoppages and, consequently, to high repair costs. In addition, the chemical and physical parameters can vary considerably in the case of natural titanium
20 carriers, so that they cannot be used, or can be used only with considerable risks, in the manufacture of steel of which high demands are made in terms of quality.

25 Because of the greater fineness of the particles of synthetic titanium carriers, advantages arise not only with regard to negligible wear of the blowing-in device, but also in that the course of the desired reactions is accelerated kinetically because of the larger specific
30 surface area of the comparatively finer particles of the synthetic titanium carrier.

The synthetic titanium carriers introduced may consist of pure titanium dioxide, whose particles have a mean
35 particle size at 100 % of up to 200 μ m.

A preferred embodiment of the method according to the invention consists in the use of synthetic titanium carrier that contains, in addition to titanium dioxide, up to 95 wt.%, preferably from 20 to 80 wt.%, iron oxides such as Fe_2O_3 , FeO_2 , Fe_3O_4 .

The titanium carrier can also contain one or more of the components calcium oxide, silicon oxide, aluminium oxide and magnesium oxide.

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Because of the fineness of the particles and the large specific surface area, the iron-oxide-containing titanium carrier blown into the arc furnace melts immediately. In conjunction with the carbon blown in at the same time, both the iron oxide and the titanium dioxide are immediately reduced to elemental iron and titanium. The reduced titanium dissolves in the metallic iron droplets and reacts immediately thereafter with the carbon which is present in excess and is likewise dissolved in the fine iron droplets, to form titanium carbide. Because of the extremely high temperatures of an arc of up to 3000°C , the content of nitrogen in the atmosphere and hence also in the liquid slag layer and the molten metal is frequently concentrated. If the fine, molten iron droplets enriched with titanium come into contact with the slag and molten metal enriched with nitrogen, titanium nitride and titanium carbo-nitride form which, like titanium carbide, are extremely highly refractory and resistant to attack by oxygen and have very high resistance to physical erosion and chemical corrosion.

The formation of those titanium compounds is a pure phase boundary reaction and takes place especially at the surface of the iron droplets. As a result, a dense layer of those titanium compounds is formed at the surface of the droplets. The titanium compounds are

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immediately deposited on the contact surfaces, that is to say the furnace lining and/or the graphite electrodes, during foaming of the slag. The iron droplets then freed of the titanium compounds slowly
5 sink into the molten steel owing to their higher specific weight.

The pure crystals, once deposited on the surface of the furnace lining and/or the graphite electrodes,
10 increasingly grow together to form complex wear-resistant titanium compounds and form a permanent layer that is resistant to corrosion and erosion even when the foamed slag collapses and frees the surface to be protected again. Because of the high grain fineness, the
15 titanium compounds formed can be introduced by macroscopic transport processes into the porous surfaces of the furnace lining and/or of the graphite electrodes, and in some cases they also diffuse into the tiny pores. The optimum closure of the micropores prevents further
20 penetration of slag and gases and thus protects deep into the furnace lining and/or the graphite electrodes.

The advantages achieved with the invention are especially that the finely divided titanium carriers can
25 be introduced without difficulty into the arc furnace, alone or in admixture with carbon carriers, and, owing to their large specific surface area, cause a very rapid reaction kinetics. The content of titanium carrier, based on the carbon content, is from 1 to 80 %. Within a
30 short time, highly refractory, corrosion- and erosion-resistant titanium carbides, titanium nitrides and titanium carbonitrides form, which are deposited on the surface of the furnace lining and the graphite electrodes and in some cases diffuse into the coarse
35 inner pores; a layer of intergrown crystals of different titanium compounds forms, ensuring permanent protection even after the foamed slag layer has collapsed.

It is also advantageous that, if required, the titanium carriers can be blown in locally in the region of an area of damage that is to be repaired.